ISSN 0838-1992

W.F. Warwick

Aquatic Ecology Division
National Hydrology Research Institute
Environment Canada
Saskatoon, Saskatchewan
S7N 3H5

CHIRONOMIDS, LAKE DEVELOPMENT AND CLIMATE: A COMMENTARY

Journal of Paleolimnology
2(1), 15-17, 1989

NHRI Contribution No.89006

1989

90-06483/

89006

WARWICK, W.F., 1989. Chironomids, lake development and climate: a commentary. Journal of Paleolimnology, 2(1), 15-17

ABSTRACT

Warwick discusses the controversy concerning chironomid remains as indicators of palaeoclimate. In reviewing the results obtained by Walker and Mathewes from Mike, Misty and Marion Lakes in British Columbia he considers the differences between responses to climatic amelioration and trophic change and the apparent effects of the Mazama ashfall. The driving forces behind chironomid community changes in the lakes studied appears to be the interplay between mineral sediment accumulation and the availability of organic food resources rather than direct temperature change.

89006

WARWICK, W.F., 1989. Chironomids, lake development and climate: a commentary. Journal of Paleolimnology, 2(1), 15-17

RÉSUMÉ

Journal of Paleolimnology 2: 15–17, 1989.
© 1989 *Kluwer Academic Publishers. Printed in Belgium.*
NHRI Contribution No. [illegible]

Chironomids, lake development and climate: a commentary

William F. Warwick
National Hydrology Research Institute, Aquatic Ecology Division, 11 Innovation Blvd., Saskatoon, Saskatchewan, S7N 3H5, Canada

Accepted 11 January 1989

Key words: Chironomidae, palaeolimnology, sedimentation effects

The controversy concerning chironomid remains as indicators of palaeoclimate (Warner & Hann, 1987; Walker & Mathewes, 1987a) originates largely from the emphasis placed on climate as the driving force behind the decline in the late-glacial *Heterotrissocladius* assemblage in Marion Lake (Walker & Mathewes, 1987b) and in Mike and Misty lakes (Walker & Mathewes, 1989). Although passing reference was made to trophic change in the Marion Lake paper, Walker & Mathewes argued that the principle factor leading to decline in the cold stenothermous fauna was climatic amelioration (= warming) towards the close of the Pleistocene. More consideration is given in their 1989 paper to other factors, but emphasis still remains largely on temperature. Climate undoubtedly has some influence on chironomid assemblages in lakes, but how close is the connection? Does it include a direct temperature component as Walker and Mathewes imply?

Water depth is a major factor influencing chironomid communities in lakes. During the late-glacial period, each of the lakes was comparatively deep – between 12–13 m in Mike and Misty lakes and 14–15 m in Marion Lake. If present-day Mike Lake stratifies at 6.5 m depth, then stratification almost certainly occurred at these greater depths. As Walker & Mathewes (1987b) state, 'deep-water chironomids of stratified lakes are isolated from the direct effects of changing air temperature...'. Thus, water depth almost certainly rules out the direct influence of climatic warming.

Substrate also exerts a strong influence on chironomid communities. Walker & Mathewes (1989) state that early postglacial faunal changes correlate poorly with lithological changes. And yet there is clear evidence of sediment/fauna interactions, the most obvious of which are associated with the Mazama ash layer. Taxa like *Heterotrissocladius*, *Procladius*, *Zalutschia*, *Parakiefferiella* cf. *bathyphila* (sub *P. nigra* in Marion Lake?), *Parakiefferiella* cf. *triquetra* (sub *P.* sp. *B* in Marion Lake?), *Stempellinella* and *Limnophyes* responded positively to the injection of volcanic ash in Mike and Marion lakes. Conversely, taxa like *Chironomus*, *Sergentia*, *Tanytarsus* and *Corynocera* cf. *ambigua* responded negatively.

These responses provide an important key for interpreting the late-glacial sediments. The species of *Heterotrissocladius* found in these sediments most likely was *H. latilaminus*. According to Saether (1975), it occurs at all depths in Marion Lake and can tolerate a wide range of biotopes from littoral to profundal and oligotrophic to slightly eutrophic. From its association with the Mazama ash layer, it also appears to be sediphilic*. This is not surprizing as other species of the genus bear the same proclivity. *Heterotrissocladius marcidus*, which occurs in small num-

* I define *sediphilic* as those taxa responding positively to the accumulation of mineral sediments.

bers in the littoral zone of Marion Lake, lives equally well on organic or mineral substrates (Saether, 1975). *Heterotrissocladius changi* Saeth. responded positively to the accumulation of mineral sediments in the Bay of Quinte (Warwick, 1980a). As a eurytopic sediphile, *H. latilaminus* would hardly fit the role of an oligotrophic, cold-stenothermous element.

The second most important taxon from the point of view of sediment interpretation was *Parakiefferiella* sp. *A*. Although not present at the Mazama ash layer, supplementary information on the taxon comes from Warwick (1980b). The abundance of *Parakiefferiella* sp. *A* (sub. Gen. nr. *Heterotrissocladius*) increased sharply during the early stages of the 1852-53 influx of mineral sediments, but reached peak abundance in the aftermath of maximum deposition. It was followed by *Heterotrissocladius* which reached maximum abundance slightly later when accumulation rates had declined. While both prefer unstable, highly mineral sediments, *Parakiefferiella* sp. *A* appears to be slightly more tolerant.

These observations are important when applied to the late-glacial faunal changes. In Mike Lake, *Heterotrissocladius* was most abundant initially in the clay-gyttja sediments at ca. 6.35 m. The taxon began to decline in abundance (ca. 6.30 m) as the sediments changed to gyttja and organic concentrations neared 20%. The deposition of a thin compact layer of clay around 6.27 m sharply depressed organic concentrations to <5% and *Heterotrissocladius* increased in abundance at the expense of sediphobic species like *Chironomus*. The reversal was short-lived, however, and as organic concentrations again climbed above 20%, *Heterotrissocladius* declined once more to disappear above 5.80 m as organic concentrations exceeded 30%.

Although not described by Walker & Mathewes (1989), a second sedimentary event is suggested by an increase in *Parakiefferiella* sp. *A* and a decrease in *Chironomus* at ca. 5.80 m. Organic concentrations remained above 20%, however, and there was no indication of a revitalized *Heterotrissocladius* population.

In Misty Lake, the scenario is simpler. *Heterotrissocladius* was most abundant in the sediments immediately overlying the basal clay sediments at ca. 7.40 m. The taxon then declined steadily as organic concentrations increased and was phased out above 7.00 m as these exceed 30%.

In Marion Lake, similar sequences are apparent even though ignition data are lacking. The abundance of *Parakiefferiella* sp. *A* peaked twice in the late-glacial sediments at ca. 8.80 m and 8.45 m to mark two accumulation episodes as noted for Mike Lake. Both episodes were further marked by concurrent increases in the abundance of *Heterotrissocladius* at ca. 8.65 m and 8.25 m. As in the Bay of Quinte, *Heterotrissocladius* here too seems to be slightly less sediphilic than *Parakiefferiella* sp. *A*.

Walker & Mathewes (1987b, 1989) argue that the disappearance of late-glacial *Heterotrissocladius* communities from Europe and North American lakes was climatically driven. But the changes noted here are clearly linked to sedimentary processes. The question then becomes what kind of sedimentary process could apply synchronously, across a wide geographic area and in such a variety of biotopes? The only single common denominator seems to be the manner in which maturation of bottom sediments takes place. Fauna colonizing the relatively sterile mineral sediments left after deglaciation would necessarily be tolerant of unstable bottom conditions. However, as beachlines and surrounding catchment areas stabilize and ground cover develops, the ratio between organic and mineral increments to the sediments change and with them the composition of their resident communities. As organic concentrations increase, sediphilic taxa like *Heterotrissocladius* can no longer compete and are phased out in favor of species like *Chironomus* which require stable bottom sediments and readily accessible food resources.

The importance of the ratio between organic and mineral sediment fractions is shown by the response of *Heterotrissocladius* to the Mazama ash layer. In Mike Lake, the injection of ash at 4.25–4.28 m reduced organic concentrations below 5% and *Heterotrissocladius* reappeared.

The taxon then persisted in the sediments, albeit in small numbers, as long as organic concentrations remained below 30%, but as soon as this was exceeded, *Heterotrissocladius* was phased out once more.

The same sequence was repeated in Marion Lake. *Heterotrissocladius*, which persisted in small numbers up to 6.10 m, increased sharply in abundance following the injection of Mazama ash and remained relatively abundant up to 4.1 m before entering a decline phase at ca. 3.00 m.

The persistence of *Heterotrissocladius* in the post-Mazama sediments of Mike and Marion lakes coincides with the western hemlock maximum during which cooler and wetter conditions prevailed. In view of their responsiveness to the sedimentary environment, it is not hard to envisage increased allochthonous inputs washed into the lakes as the driving force maintaining these fauna. Mathewes (1973) acknowledged that sedimentation rates in Marion Lake were quite variable and that much of the material was 'allochthonous in origin, brought in by the stream and perhaps slope wash'. The four-fold difference in catchment size almost undoubtedly accounts for the greater sediment depth in Marion Lake. It may be that this factor, too, accounts for the difference in size of the *Heterotrissocladius* communities in the two lakes.

If cooler, moist conditions were responsible for these relatively strong *Heterotrissocladius* communities through the increased accumulation of allochthonous materials, it is not hard to envisage the effect of the drier, warmer climate of the xerothermic interval on these communities. With little input of allochthonous materials from outside sources, *Heterotrissocladius* disappeared altogether from Mike Lake sediments and was very much reduced in Marion Lake. Although climatically driven in the broadest sense, these changes were wrought by reduced rainfall or runoff rather than temperature *per se*.

The driving force behind chironomid community changes in these lakes appears to be the interplay between mineral sediment accumulation and the availability, both in qualitative and quantitative terms, of organic food resources rather than direct temperature change. It is unfortunate that the sediment properties of Marion Lake were not fully characterized and the effects of sediments and lake trophy analyzed in Walker & Mathewes' (1987b) initial study; fortunately the sediments of nearby Mike Lake can serve as a surrogate for interpretation purposes.

References

Mathewes, R. W., 1973. A palynological study of postglacial vegetation changes in the University Research Forest, southwestern British Columbia. Can. J. Bot. 51: 2085–2103.

Saether, O. A., 1975. Nearctic and Palaearctic *Heterotrissocladius* (Diptera: Chironomidae). Bull. Fish. Res. Bd Can. 193: 67 p.

Walker, I. R. & R. W. Mathewes, 1987a. Chironomids, lake trophic status, and climate. Quat. Res. 28: 431–437.

Walker, I. R. & R. W. Mathewes, 1987b. Chironomidae (Diptera) and postglacial climate at Marion Lake, British Columbia, Canada. Quat. Res. 27: 89–102.

Walker, I. R. & R. W. Mathewes, 1989. Early postglacial chironomid succession in southwestern British Columbia, Canada, and its paleoenvironmental significance. J. Paleolimnology.

Warner, B. C. & B. J. Hann, 1987. Aquatic invertebrates as paleoclimatic indicators. Quat. Res. 28: 427–430.

Warwick, W. F., 1980a. Palaeolimnology of the Bay of Quinte, Lake Ontario: 2800 years of cultural influence. Can. Bull. J. Fish. Aquat. Sci. 206: 117 p.

Warwick, W. F., 1980b. Chironomidae (Diptera) responses to 2800 years of cultural influence: a palaeolimnological study with special reference to sedimentation, eutrophication, and contamination processes. Can. Entomol. 112: 1193–1238.